

The Galileo Messenger

Issue 43

May 1997

From the Project Manager

Project Galileo continues to perform superbly. Yes, *Project Galileo*—not just our magnificent spacecraft, but equally important, the hundreds of people on the ground that make it work. The people of the Project Team, including our German propulsion colleagues here and there, Galileo scientists worldwide, the people in the JPL Multimission Ground Systems operations, and those in the Deep Space Network at Pasadena and the tracking sites in California, Spain, and Australia, including the folks at Australia's Parkes 64-m antenna. The ensemble of all the things that must be done on a continuing basis to "operate" Galileo is truly mind-boggling. The lead time ranges from years to at times only minutes. It is an enormous plan of steadily increasing detail as a set of observations or a downlink nears. And, quite often, contingencies require the most insightful troubleshooting and recovery actions. It is a global team of the first magnitude.

Since the last *Messenger* just 2 months ago, the Ganymede-7 and Ganymede-8 encounters have been successfully performed—Galileo is now 7 for 7 orbital tour satellite encounters, less than 1 year since starting with Ganymede-1 in June 1996. Once again these recent encounters were punctuated with skillful real-time anomaly recoveries. Less than a day before Ganymede-7 closest approach,

—see page 4

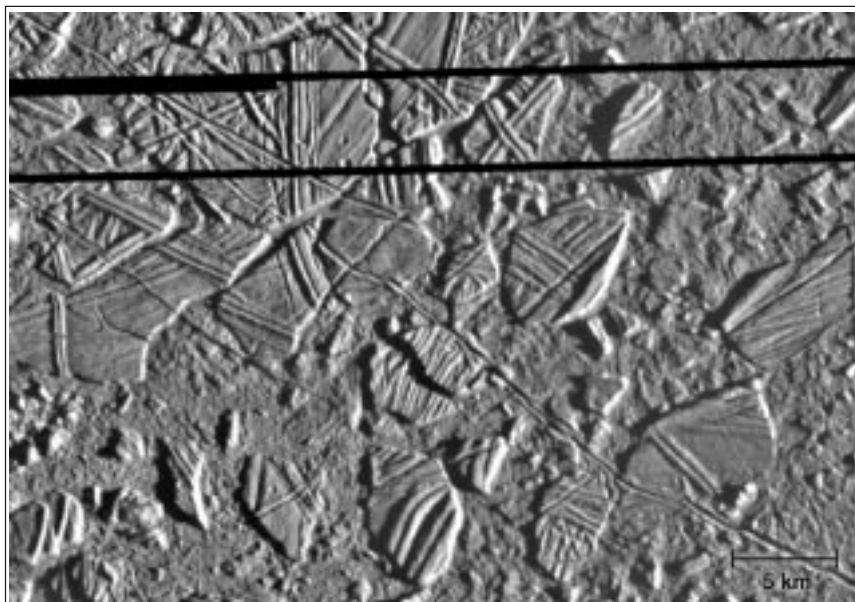
An Ocean Discovered: Europa Surrenders Her Secrets

Sixteen months into the Jovian system tour, public interest has shifted increasingly towards Europa—the newest superstar on the celestial stage. Prospects for subsurface water, and with it, life, have never looked brighter.

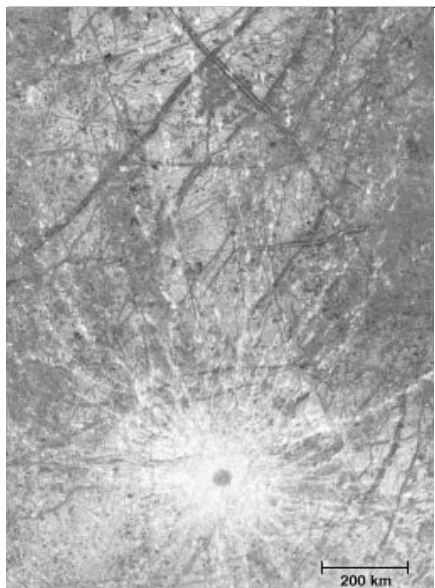
Floating Icebergs?

When the Galileo Orbiter swooped within 587 km (363 mi.) of Europa's icy crust, on the E6 pass of February 20, its Solid-State Imaging (SSI) camera captured an array of breathtaking, mind-blowing images. The panel of eight investigators (moderated by David Seidel) that reviewed the E6 science on April 9 at JPL's von Kármán Auditorium was certainly the most diverse Galileo group, and perhaps the most excited, to face the international press.

Michael Carr of the U.S. Geological Survey was not new to the crowds at von Kármán, but his previous appearance had been to discuss hidden water on Mars. Now, in his first appearance on a Galileo panel, he spoke of hidden water on Europa. Seated below a large, full-color image of the European surface, he maintained Galileo had discovered the "smoking gun" that indicates the signature of a subsurface ocean in the place where nature marked the



Europa's ridged crust, broken into "icebergs" that have slid, turned, and tipped.



Low-resolution image of the trailing hemisphere. Note patches of dark and light terrain.

spot with a large “X.” The image above, centered over the trailing hemisphere, showed the bright crater Pwyll to the south, and, near the northern edge, two dark-red triple bands, one crossing the other at a right angle—the “X.” And just south of the intersection, an irregular dark-red patch, maybe 50-km wide. This was the patch from which Robert Sullivan, of Arizona State University, had introduced (only minutes before) the celebrated image of the European icebergs, floating in their now-frozen sea (see p. 1). Carr was visibly impressed with the way these enormous, 3-to-6-km-wide blocks, scarred with ridges, were tipped and rotated. This motion, he explained, could not be accounted for by wind or slope, but could be caused only by the traction of currents in a liquid medium.

Paul Geissler from the University of Arizona, and also new to the panel, concurred. The tilted bergs, he explained, showed just how thin the surface here was—perhaps only 1-or 2-km thick! [Thin indeed compared to a 100-km (60 mi.) deep ocean.] Geissler also explained that convection in solid ice (suspected on Ganymede) could not account for all the observed movement. And the lack of any feature higher or

deeper than a few hundred meters would be consistent with a 1- or 2-km layer of floating ice [remember, icebergs are 90 percent below the surface].

Max Coon of the Northwest Research Association displayed a picture of pack ice in the open water of the Earth’s own Arctic Ocean for comparison. Such floes, he explained, frozen in a winter sea, would resemble Europa’s bergs even more closely. Open water on Europa would boil and freeze at the same time; the rapid freezing would seal in further loss; the water vapor released into space would settle as snow and help color the whitest, brightest surface in the solar system.

Diverse Features

Larger areas of the surface show a bewildering complexity of features (see below). Here, the icebergs appear to be frozen in an area surrounded by sound, unbroken, grooved crust. Yet portions of this crust also show smaller areas within which the surface seems to have melted, then refrozen as a choppy, rubbly patch that obliterates the older pattern of ridges and grooves.

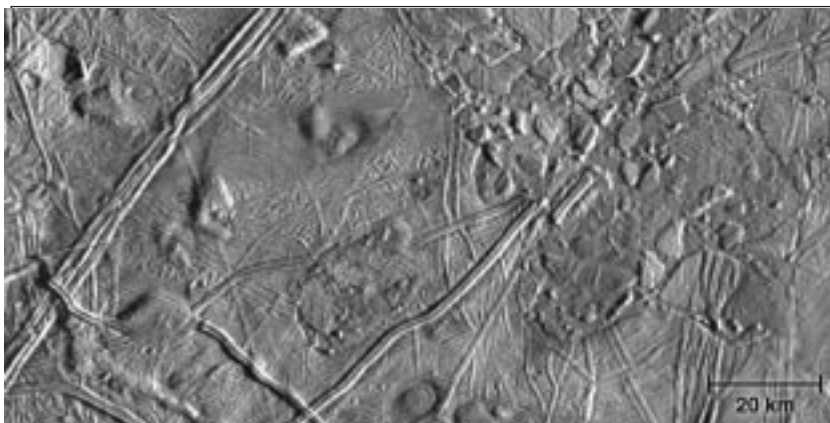
Even stranger, some areas look as smooth and flat as skating ponds. Sullivan’s introduction included the image from the E4 pass (see p. 3, top left) that showed both a sharp-edged, jumbled patch and a smooth, flooded area. These two features are separated by only

5 km, yet the older, eastern one shows what may have been the sudden collapse of a 4-km-wide section of crust that refroze as a mass of broken, floating chunks; the younger, western one shows what may have been the gradual sinking of an equally wide area and a gentle flooding from below.

How Old a Surface?

Close up, neither of these features shows even the slightest resemblance to impact craters, but from a distance they appear dark against the whiter, ridged crust. As “freckles,” they were considered impact craters and included in preliminary counts. Clark Chapman, of the Southwest Research Institute, noted that this confusion resulted in crater counts about 100 times greater than now observed! This means a surface proportionately much younger, maybe even less than a million years. This is a geological eye blink, and Chapman credited only the Earth and Io with more active crusts.

Michael Carr, echoing some of the passion in the surface-dating debate, pointed out that the cratering rate in the Jovian neighborhood is much less well known than the rate around the Earth and the surface could be much older. Given such uncertainty, Clark Chapman thought it might even be younger, while Torrence Johnson, Project Scientist from JPL, felt that even much older than a million years would still be geologically young.



A variety of features are visible in this blowup of an area just below the X in the image at the top of this page.



Closeup with melt features.

The Case for an Ocean—and Life!

The evidence for a deep ocean, then as Richard Terrile from JPL, suggested, is “strong.” If, he added, it underlies the whole surface, then the European ocean would contain more water than exists in all the oceans of the Earth! As best we can tell, life on Earth appeared within 700 million years of its formation, 4.6 billion years ago. From its

beginning, the European environment with abundant water, rich in dissolved minerals and organics, would be suitable for the origin of life. As old as the Earth, this moon has had time for life to evolve.

John Delaney, an oceanographer from the University of Washington, the first of that discipline at a Galileo press conference, shared some of his passion for exploring the European ocean and discovering life. He noted that about the time

the Voyagers were downlinking the first pictures of Europa’s flat, icy crust, deep-diving oceanographers were discovering the first volcanic-vent communities on the Eastern Pacific sea floor.

Delaney could confidently report that today, wherever sea-floor volcanism is found, so will be rich and diverse life. This suggests a new biological paradigm—a new way to view life: wherever you find volcanic activity and liquid water, even *within* rock, you will find life.

The panel speculated on possible follow-on missions to Europa—orbiters to map the sub-surface water, “cryobot” penetrators to reach the hidden sea, and “hydrobot” submersibles to plumb its sunless depths.

As Project Galileo continues to study Europa’s mysteries, we discover even more. Europa has proved to be a far more interesting place than ever imagined. And we’ve only begun. ❖

—Larry Palkovic

Meet the Outreach Team

Getting the Word Out

“The part of my job that I like most is translating science-ese into everyday words people understand. It’s gratifying to see so many people eager to learn about our new discoveries,” said Leslie Lowes, Lead for Galileo’s Outreach Team that conveys new findings from Galileo to educators and the public worldwide. Leslie coordinates the efforts of the Outreach Team and creates the printed materials (including brochures, posters, and slide sets featuring Galileo’s images) that inform the public and educators. Requests come in from people around the globe.

Team members include Jo Pitesky, Ron Baalke, Rebecca Westbrook, and Aimee Martinez. Jo Pitesky shapes Galileo’s scientific data into accessible classroom exercises and writes material for the Galileo Project home page, <<http://www.jpl.nasa.gov/galileo>>,

for which the Galileo Outreach Web Page Development Team won a JPL 1997 Award for Excellence last month. Jo also answers questions



The Outreach Team: (from left, standing) Ron Baalke, Rebecca Westbrook, Aimee Martinez; (seated) Leslie Lowes and Jo Pitesky surround their favorite planet.

like, Why aren’t all the science data made public as soon as they’re received? The data requires considerable processing before it can be interpreted. “We’re grateful that the scientists release so many of these important photos and other data after having only a very short time to analyze them,” said Jo. She manages other Internet educational events on the Online from Jupiter home page <<http://quest.arc.nasa.gov/project/jupiter.html>>, where students may read science team member biographies and daily activity journals. “Viewing these entries lets young people live the mission through the Internet,” said Jo.

Jo and Ron Baalke maintain the Galileo Web site; “hits” by daily visitors average over 100,000, depending on breaking news, such as last month’s Europa news conference (see story, p. 1). Ron also maintains the Galileo electronic mailing list of over 5000 subscribers. The site offers new Galileo images daily, answers questions via e-mail, and features

chat groups where several hundred people log in, many with questions for the Project and Science Teams.

Rebecca Westbrook, a co-op student from the University of Washington, is coordinating the production of the Galileo informational CD-ROM due out this summer. "Rebecca has been producing our popular, on- and off-Lab teacher workshops that demonstrate how the mission is run," said Leslie. "Her tenure at JPL is over in June, and we're sad to lose her. But we're proud to be bringing in Priscilla Beckman, a science teacher at Crescenta Valley High School, to coordinate the workshops."

Aimee Martinez, a student at Pasadena City College working part time, provides critical, skilled computer and clerical assistance.

Others support the Team in many ways. Project Scientist Torrence Johnson often is one of the first to tell Galileo's story to the media as it unfolds. Elizabeth M. Alvarez del Castillo coordinates outreach for the Solid-State Imaging (SSI) Team that provides the bulk of the image-per-day capability for our Web page and designs classroom activities around these images from Galileo's camera. Maynard Hine, who designs displays for the group (and a new touring exhibit), worked with Leslie to produce the three-fold, "Travels of Galileo." Ed Hirst writes the "This Week on Galileo" story for our Home Page and keeps us current on mission planning activities. Tiffany Chiu is responsible for the product inventory. Bill Hoffman supports the art work needed. Valerie Pickett answers individual requests for Galileo material. And Jan Ludwinski, Chief, Mission Planning Office (that includes the outreach function), acts as consultant.

Leslie just returned from conducting a seminar at the National Science Teachers Association Conference in New Orleans. In her free time, she sings in three choirs and loves to ride her bike with friends; twice she has biked from Pasadena to San Diego.❖

— Tom Wilson

PROJECT MANAGER from page 1

celestial reference was lost when the bright body protection "blocked" one of the two stars being used. The problem was diagnosed, and a different star was substituted by real-time commanding just hours before closest approach. Two days before Ganymede-8, it was discovered that the inboard Magnetometer sensor was opposite the planned orientation (flip), and the corresponding transformation matrix had to be real-time commanded several times throughout the encounter.

This past week, the Project Science Group (PSG) held its quarterly meeting at JPL. Excellent progress was made in planning the science observations for the Galileo Europa Mission (GEM). One day of these PSG meetings is now devoted to reports by the investigators of their latest science results. These reports show the tremendous breadth, quality, and quantity of science Galileo is providing. Publicly, the pictures from Galileo's Solid-State Imaging (SSI) camera always steal the show, just as in this issue of *The Messenger*, highlighting the "mind-boggling" European icebergs. There are ten other instruments on the Galileo Orbiter and two radio science investigations, all of which are providing excellent scientific results. We continue to struggle to find better ways to communicate the excitement and importance of the non-imaging data to the general public. Just a few examples: the Radio Science Celestial Mechanics Investigation "senses" the internal structure of the satellites and has discovered that Io, Europa, and Ganymede all have dense cores while Callisto is uniform throughout. The fields and particles instruments have discovered that Ganymede is magnetized, possibly Io as well, Callisto definitely not, and Europa yet to be determined. And they continue to map the composition and dynamics of Jupiter's lethal magnetosphere—the largest volume in our

solar system at one-hundred times the volume of the Sun. This summer between the Callisto-9 and Callisto-10 encounters, Galileo carries these instruments 10 million kilometers deep into the magnetotail opposite the Sun to achieve one of Galileo's most important science objectives.

The Near-Infrared Mapping Spectrometer (NIMS) is providing excellent data to study the surface chemistry of the satellites, including volcanic hotspots on Io, and is, in effect, doing water sounding over the Jupiter globe—to mention just some of its contributions. The water sounding is providing important information about one of the major puzzles from the Probe observations—the apparent underabundance of water. NIMS data are showing that local water abundance below the clouds varies widely across the planet, suggesting that, indeed, Jupiter weather dried out the region where the Probe descended.

By the way, the original, official Project Plan for Galileo published in 1978 had *NO* encounters of Europa or Io, and the encounters of Ganymede and Callisto were all at or above a 1000-km altitude. Galileo has already encountered all four Galilean satellites typically at lower altitudes with a low of 261km at Ganymede-2.

Galileo is indeed superbly fulfilling its objectives at Jupiter.❖

— Bill O'Neil

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JPL 410-16-43 5/97